

Customer No.: 31561
Docket No.: 12043-US-PA
Application No.: 10/708,176

remarks.

AMENDMENTS

To the Specification:

Please amend the following paragraphs as indicated hereafter.

[0003] The present invention relates to an organic electroluminescence (OEL) device and a manufacturing method thereof. More particularly, the present invention relates to an organic electroluminescent device having an excellent luminous efficiency, long service life and high brightness, and a manufacturing method thereof.

[0008] In order to emit a white light from the conventional organic electroluminescent device 100, the emitting layer 130 is generally constructed by a blue emitting layer 132 and a reddish orange emitting layer 134. Therefore, a white light is generated by the blue light and reddish orange light that are complementary color. However, because the service life of the conventional blue emitting material is short, i.e., the decay of the blue light emitting material is faster than that of the reddish orange emitting material. Therefore, when the blue emitting layer ~~130a~~132 starts to decay, the white light emitted from the organic electroluminescent device 100 will have chromatic aberration.

[0009] Therefore, one object of the present invention is to provide an organic electroluminescent device having an excellent luminous efficiency, long service life and

Customer No.: 31561
Docket No.: 12043-US-PA
Application No.: 10/708,176

high brightness by providing a dark-blue emitting layer and a light-blue emitting layer, and manufacturing method thereof.

[0013] In order to achieve the above objects and other advantages of the present invention, a manufacturing method of an organic electroluminescent device is provided. The manufacturing method includes, for example but not limited to, the following steps. First, an anode is formed on a substrate. Next, an emitting layer is formed on the anode, wherein the emitting layer includes a blue emitting layer and a reddish orange emitting layer, and the blue emitting layer includes a dark-blue emitting layer and a light-blue emitting layer. Then a cathode is formed on the emitting layer.

[0025] FIG. 2A to FIG. 2D are cross-sectional views illustrating four organic electroluminescent devices emitting a white light according to the preferred embodiments of the present invention. First, referring to FIG. 2A, the organic electroluminescent device 200 includes, for example but not limited to, a substrate 210, an anode 220, an emitting layer 230 and a cathode 240. The substrate 210 includes, for example but not limited to, a glass substrate, a plastic substrate or a flexible substrate. The anode 220 is disposed on the substrate 210. Since the anode 220 is provided for injecting electron holes into the emitting layer 230 effectively, it is preferable that the material of the anode 210 has a higher work function. The material of the anode 220 includes, for example but not limited to, an indium tin oxide (ITO), tin oxide, gold (Au), silver (Ag), platinum (Pt) or copper (Cu). The

Customer No.: 31561
Docket No.: 12043-US-PA
Application No.: 10/708,176

emitting layer 230 is disposed on the anode 220, and the cathode 240 is disposed on the emitting layer 230. The cathode 240 is provided for injection the electrons into the emitting layer 230 effectively. The cathode 240 includes, for example but not limited to, a single conductive layer, and the material of the cathode 240 includes, for example but not limited to, an aluminum (Al), calcium (Ca), magnesium (Mg) or silver (Ag) that has a low work function. The cathode 240 may be double conductive layers, and the material of the cathode 240 includes, for example but not limited to, lithium fluoride/aluminum, barium/aluminum, magnesium/silver, calcium/silver.

[0026] Moreover, the emitting layer 230 may include, for example but not limited to, a blue emitting layer 232 and a reddish orange emitting layer 234. Since the blue light emitted from the blue emitting layer 232 and the reddish orange light emitted from the reddish orange emitting layer 234 are complementary color, an organic electroluminescent device 200 emitting a white light can be achieved.

[0027] It is noted that in the present invention, the blue emitting layer 232 may include, for example but not limited to, a dark-blue emitting layer 232a and a light-blue emitting layer 232b. FIG. 3A is a spectrum of the light emitted from a dark-blue emitting layer, a light-blue emitting layer and a dark-blue emitting layer combined with a light-blue emitting layer. FIG. 3B is a diagram illustrating the service life of the emitted light from a dark-blue emitting layer and a dark-blue emitting layer combined with a light-blue emitting

Customer No.: 31561
Docket No.: 12043-US-PA
Application No.: 10/708,176

layer. In FIG. 3A, the horizontal axis is wavelength and the vertical axis is light intensity. It is noted that, in curve C3, the wavelength of the light emitted from the dark-blue emitting layer is shorter, therefore a blue color having a better brightness and performance is obtained after passing through the color filter. In addition, in curve C1, the light emitted from the light-blue emitting layer includes a portion of blue light and a portion of green light, and the curve C1 can be provided for enhancing the luminous efficiency and the whole brightness of the white light organic electroluminescent device. In curve C2, when the dark-blue emitting layer and the light-blue emitting layer are provided simultaneously, the color gamut of the blue light is widest. Next, in FIG. 3B, the horizontal axis is time and the vertical axis is light intensity. A light-blue emitting layer having a more stable morphology has a longer service life and can stabilize the adjacent material layer.

[0028] In the embodiments of the emitting layer of the invention, the blue emitting layer 232, for example but not limited to, is disposed on the anode 220 and the reddish orange emitting layer 234, for example but not limited to, is disposed between the blue emitting layer 232 and the cathode 240. Referring to FIG. 2A, the dark-blue emitting layer 232a, for example, is disposed on the anode 220, and the light-blue emitting layer 232b, for example, is disposed between the dark-blue emitting layer 232a and the reddish orange emitting layer 234. Alternatively, referring to FIG. 2B, the light-blue emitting layer 232b, for example, is disposed on the anode 220, and the dark-blue emitting layer 232a, for example but not limited to, is disposed between the

Customer No.: 31561
Docket No.: 12043-US-PA
Application No.: 10/708,176

light-blue emitting layer 232b and the reddish orange emitting layer 234.

[0029] Alternatively, the reddish orange emitting layer 234 may also be disposed on the anode 220, and the blue emitting layer 232 may be, for example, disposed between the reddish orange emitting layer 234 and the cathode 240. Referring to FIG. 2C, the dark-blue emitting layer 232a, for example but not limited to, is disposed on the reddish orange emitting layer 234, and the light-blue emitting layer 232b, for example but not limited to, is disposed between the dark-blue emitting layer 232a and the cathode 240. In addition, Referring to FIG. 2D, the light-blue emitting layer 232b, for example but not limited to, is disposed on the reddish orange emitting layer 234, and the dark-blue emitting layer 232a, for example but not limited to, is disposed between the light-blue emitting layer 232b and the cathode 240.

[0032] Referring to FIG. 2A, the organic electroluminescent device 200 further includes, for example but not limited to, a hole-injecting layer (HIL) 272, a hole-transporting layer (HTL) 274, an electron-transporting layer (ETL) 276 and an electron-injecting layer (EIL) 278. The hole-injecting layer (HIL) 272, for example but not limited to, is disposed between the emitting layer 230 and the anode 220. The hole-transporting layer (HTL) 274, for example but not limited to, is disposed between the emitting layer 230 and the hole-injecting layer (HIL) 272. Moreover, the electron-transporting layer (ETL) 276, for example but not limited to, is disposed between

Customer No.: 31561
Docket No.: 12043-US-PA
Application No.: 10/708,176

the emitting layer 230 and the cathode 240. The electron-injecting layer (EIL) 278, for example but not limited to, is disposed between the cathode 240 and the electron-transporting layer (ETL) 276.

[0033] Moreover, the material of the host of the blue emitting layer 232 includes a 9,10-diarylanthracene as shown in FIG. 4A, wherein Ar and Ar' are aryl groups and R is alkyl group or aryl group. The 9,10-diarylanthracene includes, for example but not limited to, a 9,10-diphenylanthracene (DPA), a 9,10-bis(2-naphthalenyl) anthracene (ADN) or a 2-(1,1-dimethyl)-9,10-bis(2-naphthalenyl) anthracene (TBADN) as shown in FIGS. 4B to 4D sequentially. The host of the blue emitting layer 232 may also includes, for example but not limited to, distyrylarylene (DSA) as shown in FIG. 4E, wherein Ar, Ar1, Ar2, Ar3 and Ar4 are aryl groups. The distyrylarylene (DSA) includes, for example but not limited to, a DPVBi or a 9,10-bis[4-(2,2-diphenylethenyl)phenyl]anthracene as shown in FIG. 4F and FIG. 4G. Moreover, the dopant of the blue emitting layer 232 includes, for example but not limited to, an amino substituted distyrylarylene (DSA-amine) as shown in FIG. 4H or FIG. 4I, or a perylene compound as shown in FIG. 4J or FIG. 4K. Whether the emitting layer is a dark-blue emitting layer 232a or a light-blue emitting layer 232b is decided by the doping concentration of the dopant, wherein the doping concentration is, for example but not limited to, in a range of about 0.01% to about 50%.

Customer No.: 31561
Docket No.: 12043-US-PA
Application No.: 10/708,176

[0034] Next, referring to FIG. 2A to FIG. 2D, the manufacturing method of the organic electroluminescence device 200 of the present invention is provided. The manufacturing method includes the following steps. First, an anode 220 is formed on the substrate 210. Next, an emitting layer 230 is formed on the anode 220. The emitting layer 230 may include, for example but not limited to, a blue emitting layer 232 and a reddish orange emitting layer 234. Moreover, the blue emitting layer 232 may include a dark-blue emitting layer 232a and a light-blue emitting layer 234a. Then a cathode 240 is formed on the emitting layer 230. In addition, the method of forming the anode 220 and the cathode 240 includes, for example but not limited to, an evaporation method or a sputtering method.

[0035] Moreover, the method of forming the emitting layer 230 includes, for example but not limited to, the following four methods. (a) A dark-blue emitting layer 232a, a light-blue emitting layer 232b and a reddish orange emitting layer 234 are sequentially formed on the anode 220 as shown in FIG. 2A. (b) A light-blue emitting layer 232b, a dark-blue emitting layer 232a and a reddish orange emitting layer 234 are sequentially formed on the anode 220 as shown in FIG. 2B. (c) A reddish orange emitting layer 234, a dark-blue emitting layer 232a and a light-blue emitting layer 232b are sequentially formed on the anode 220 sequentially as shown in FIG. 2C. (d) A reddish orange emitting layer 234, a light-blue emitting layer 232b and a dark-blue emitting layer 232a are sequentially formed on the anode 220 sequentially as shown in FIG. 2D.

Customer No.: 31561
Docket No.: 12043-US-PA
Application No.: 10/708,176

Moreover, the method of forming each color emitting layer includes, for example but not limited to, an evaporation method or a coating method.

[0036] In addition, the manufacturing method of the organic electroluminescent device 200 of the present invention further includes, for example but not limited to, sequentially forming a hole-injecting layer (HIL) 272 and a hole-transporting layer (HTL) 274 after the step of forming the anode 220 but before the step of forming the emitting layer 230. Alternatively, the manufacturing method further includes, for example but not limited to, sequentially forming an electron-transporting layer (ETL) 276 and an electron-injecting layer (EIL) 278 after the step of forming the emitting layer 230 but before the step of forming the cathode 240. The method of forming the hole-injecting layer (HIL) 272, hole-transporting layer (HTL) 274, electron-transporting layer (ETL) 276 and electron-injecting layer (EIL) 278 include, for example but not limited to, a spin coating method.

Customer No.: 31561
Docket No.: 12043-US-PA
Application No.: 10/708,176

To the Title:

Please substitute the following title for the pending title as suggested in the Office Action.

~~ORGANIC ELECTROLUMINESCENCE DEVICE AND MANUFACTURING~~
~~METHOD THEREOF WITH LIGHT AND DARK BLUE EMITTING LAYERS~~